THE PRODUCTION PLANNING FOR PROFIT MAXIMIZATION (A CASE STUDY AT A COCOA PROCESSING INDUSTRY)

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Chokato is name of a cocoa processing plant in Payakumbuh, West Sumatra. It is a small scale industry that produced some kinds of processed cocoa products. Although the plant has been in production more than two years, but have not been able to achieved the maximum capacity and unknown amount of each type of product that could be reach the optimal profit. This research aimed to determined the optimal production quantity of each product to maximized the total profit, to found out maximum level of production capacity and its utilization level. The method used to was Linear Programming (LP) There were eight scenario models that tested with various production target for each product.The computation was done by Lingo 10.0 where the results indicated six models produced a feasible solution. Next, the model solutions must be adjusted due to some products were interdependent namely pure powder, 3in1 powder, and butter. Model-1 gives a maximum profit of Rp. 23.982.375 per month by producing pure powder 110,5 kgs, butter 59,5 kgs, candy-chocolate 7,6 kgs and scrubs 268,1 kgs. Total maximum capacity of plant that could be reached at optimal profit was 445,7 kg per month. On average models indicated that utilization level of two machines were above 80% and 10 machines were below 10%. Production capacity of the plant could be increased by improving capacity of machines that have high utilization level.

***Keywords**: production planning, optimal profit, capacity, linear programming*

1. INTRODUCTION

Cocoa processing industry is one of the priority industries to be developed in the province of West Sumatra. (Departemen Perindustrian, 2007). This is supported by the availability of raw materials cocoa beans and supported by central and local government. Agro-industrial development encouraged by the government in order to improve the local economy, especially the farmers. There is now a small-scale cocoa processing factory located in Payakumbuh which produces various kinds of processed cocoa products. The plant is managed by Tanjung Subur farmer groups and the plant is named Chokato (stands for Chocolate Kapalo koto). The plant produces chocolate ferment with production quantities are still low. Raw materials were supplied from cocoa farmers in the surrounding area Payakumbuh. This plant has been in operation since February 2012.

But until now the plant has not been able to opelevel optimally in which the average actual capacity about 5-6 kgs chocolate per day. Some problems were encountered, among others are; discontinuity availability of raw materials cocoa beans that are still dependent on the cocoa harvest season, the imbalance in the capacity of cocoa processing machines, and nonproductive of employees' work time. During this time, the plant manager in making of planning production quantities only based on his intuition and not performed analysis and made estimates in depth so it was not known what level of production for each product that could maximize the profit. Besides, it was not known in detail about usage of the utilization level of the machines capacity.

Several past studies that have object of research about cocoa processing industry include Anwar, et al. (2014) conducted study of stlevelgies for improving the quality of local chocolate products, Hasibuan (2012) conducted study about development policy in macro scale, Mochtar and Darma (2011) conducted financial analysis, Aisman et al.

(2008) conducted techno-economics and feasibility, and Syarfi et al. (2008) conducted study about prospect of the industrial development. From survey of methods in production planning that maximizes profit of firm obtained was that Linear Programming (LP) method is widely used because of its reliability and it has supported by software in solution searchs. Some of these studies are Gultom et al. (2013) with the application of the palm oil industry (CPO), Balogun et al. (2012) on the soft-drink industry, and Imam Hassan (2009) on the electronics industry, Khan et al. (2011) on the the chemical industry, and Herman (2008) on the tire industry.

The purposes of the research were to determined the number of production of each product that could maximize profit, to determined the maximum capacity of the plant, and to determined utility level of capacity factory machines. This study contributed to the application of Linear Programming method in problems of production planning and analysis capacity of plant resources (materials and processing machines)

2. THEORETICAL BACKGROUND

Production planning process consists of three stages, namely, manufacturing and marketing data preparation, generation of production items and selling alternatives, and production plan formulation. (Chopra and Meindl, 2001). Linear programming (LP) involves the planning of activities to obtain an optimal result among all feasible alternatives. (Hillier, 2001). The LP model has three basic components ; decision variable, objective (goal), and constraints. The properties of LP model ; proportionality, additivity, and certainty. (Taha, 2007). In maximization problem, LP model is formulated as : (Hillier, 2001)

$Max.\ Z = C_1X_1 + C_2X_2 + \ldots + C_nX_n$

Subject to

$A_{11}X_1 + A_{12}X_2 + \ldots + A_{1n}X_n\ (\leq or \geq) b_1$

$A_{21}X_1 + A_{22}X_2 + \ldots + A_{2n}X_n\ (\leq or \geq) b_2$

$A_{m1}X_1 + A_{m2}X_2 + \ldots + A_{mn}X_n\ (\leq or \geq) b_m$

Non-negativity variables :

$X_1, X_2, \ldots X_n \geq 0$

3. RESEARCH METHOD

The dataset used for this research was collected from Chokato plant that located in Koto Kapalo, South Payakumbuh district, Payakumbuh, West Sumatra. The main data for this study is a secondary data that obtained from the company includes ; types and characteristics of the product, selling price, production cost, raw materials, types of machine and equipment, process flow, capacity of machines, cycle time of process, number of production, working day and other data related. The variables in this study are monthly production of each type of product, the value of profits, capacity utilization of plant resources.

The analysis was carried out using Linear Programming (LP) method. LP model consists of objective function equation (maximizing profit) : $Max.\ Z = \sum CjXj$ and subject to constraints (raw materials, processing time, and demand) : $\Sigma\ AijXj \leq Bj$, where $xj \geq 0$ (non-negative). Computing is done with software Lingo 10.0 that obtained from (www.lindo.com). Summarily, solving the problem follow the steps ; collection of data (parameters), the formulation of model, searching for solutions, model validation, and interpretation of the model solution.

4. RESULT AND DISCUSSION

The first stage, collecting data (parameter). The plant produces 7 types of processed cocoa products that could be divided into 3 groups based on process similarity. Group A consists of pure powder, 3in1 powder, and butter. Group B consists of chocolate bars flavored milk (milk-chocolate), candy chocolate. Group C is chocolate scrubs. See Table 1 below for information of products.

Tabel 1 Type of processed cocoa products

Group	Products	Weight packaging (grs)	Profit per kgs (Rp)
A	Pure powder	200	60,000
	3in1 powder	250	30,000
	Butter	100	60,000
B	Milk-chocolate	75	60,000
	Dark-chocolate	75	80,000
	Candy-chocolate	16	93,750
C	Scrubs	80	48,750

The main raw materials of these products are cocoa beans, powder milk, and refined sugar. For cocoa beans, the plant more use of wet cocoa beans than dried cocoa from the farmers. It is to ensure cocoa beans get right fermentation process. Therefore, it is assumed that plant only use wet cocoa beans. Powder milk is used only for 3in1 powder, milk-chocolate, and candy-chocolate, while refined sugar is only used for 3in1 powder, dark-chocolate, and candy-chocolate. Appendix 1 on the last page presents calculation raw material requirements (coefficient) for each type of product from actual condition. Then also collected the cycle time for each stage of processing of products that obtained by interviews with managers and employees of the plant. The cycle times will be used as the standard times. Appendix 2 presents cycle time for each stage of the production process. Next, capacity of each processing machines was collected as can be seen in Appendix 3.

The second stage, formulation of LP model to represent the problem which consists of the objective function equation (maximization of profit value) with 7 decision variables (*Xj*), Constraint equations which consists of two types of constraints (3 raw materials and 14 processing time). LP models are formed has 7 x 17 in size and it is as a basic model.

Objective function:

$Max . Z = 60.000X_1 + 30.000X_2 + 60.000X_3 + 60.000X_4 + 80.000X_5 + 93.750X_6 + 48.750X_7$

Constraints of raw material :

(Wet cocoa bean)

$3,13X_1 + 1,30X_2 + 5,56X_3 + 1,30X_4 + 2,30X_5 + 1,30X_6 + 3,20X_7 \leq 1400$

(Powder milk)

$0,30X_2 + 0,30X_4 ++ 0,30X_6 + \leq 50$

(Refined sugar)

$0,30X_2 + 0,30X_4 + 0,30X_5 + 0,30X_6 + \leq 70$

Constraints of process time:

(Fermentation)

$3,16X_1 + 3,16X_2 + 3,16X_3 + 3,16X_4 + 3,16X_5 + 3,16X_6 + 3,16X_7 \leq 2850$

(Drying)

$0,15X_1 + 0,15X_2 + 0,15X_3 + 0,15X_4 + 0,15X_5 + 0,15X_6 + 0,15X_7 \leq 85,5$

(Filtering)

$0,03X_1 + 0,03X_2 + 0,03X_3 + 0,03X_4 + 0,03X_5 + 0,03X_6 + 0,03X_7 \leq 170$

(Baking)

$0,04X_1 + 0,04X_2 + 0,04X_3 + 0,04X_4 + 0,04X_5 + 0,04X_6 + 0,04X_7 \leq 170$

(Separation)

$0,05X_1 + 0,05X_2 + 0,05X_3 + 0,05X_4 + 0,05X_5 + 0,05X_6 + 0,05X_7 \leq 170$

(Milling nib)

$0,17X_1 + 0,17X_2 + 0,17X_3 + 0,17X_4 + 0,17X_5 + 0,17X_6 + 0,17X_7 \leq 170$

(Mixing)

$3,60X_4 + 3,60X_5 + 3,60X_6 + 1,80X_7 \leq 510$

(Rarefaction-1)

$1,20X_4 + 1,20X_5 + 1,20X_6 + \leq 510$

(Pressing)

$X_1 + 7X_2 + X_3 + \leq 170$

(Rarefaction-2)

$0,17X_1 + 0,17X_2 \leq 85$

(Refrigeration)

$X_1 + X_2 + X_4 + X_5 + X_6 + \leq 540$

(Rarefaction-2)

$0,17X_1 + 0,17X_2 \leq 85$

(Sieving)

$0,06X_1 + 0,06X_2 + 80X_7 \leq 170$

(Packaging)

$0,03X_1 + 0,03X_2 + 0,03X_3 + 0,03X_4 + 0,03X_5 + 0,03X_6 + 0,03X_7 \leq 170$

$X_1, X_2, X_3, X_4, X_5, X_6, X_7 \geq 0$ *(non-negativity)*

To get some alternative solutions, then made 8 model scenarios that would be tested. The scenarios were developed based on the basic model by adding some combination of production target as can be seen in Table 2 below.

Table 2. Model Scenarios

Scenarios	Constraint of Production Target
1	$X_j \geq 0$ dimana j = 1, 2, ..., 7
2	$X_1 \geq 50$, dan $X_2, X_3, X_4, X_5, X_6, X_7 \geq$
3	$X_1, X_2 \geq 50$, dan X_3, X_4, X_5, X_6, X_7
4	$X_1, X_2, X_3, \geq 50$, dan X_4, X_5, X_6, X_7
5	$X_1, X_2, X_3, X_4 \geq 50$, dan X_5, X_6, X_7
6	$X_1, X_2, X_3, X_4, X_5 \geq 50$, dan $X_6, X_7 \geq$
7	$X_1, X_2, X_3, X_4, X_5, X_6 \geq 50$, dan $X_7 \geq 0$
8	$X_1, X_2, X_3, X_4, X_5, X_6, X_7 \geq 50$

The third stage, calculation to obtain the optimal solution by software Lingo 10.0. The solution of eight models can be seen in Appendix 4. Models 1, 2, 3, 4, 5, 6 produce a feasible solution while model 7 and 8 produce an unfeasible solution. Because of the model-1 and -2 have same solution then the model-1 eliminated. For the naming of the next model, the model 2 to model 1 and so on. Next the solutions for amount of products that are in group A must be adjusted due to there is interdependence among products ; butter (X_3) product, pure powder (X_1) and 3in1 powder (X_2). In actual condition indicates relatively a ratio of the three products (X_1 + X_2) : (X_3) are 65%: 35%. The results of this adjusment as can be seen in Appendix 5. Model-1 produces the most optimal solution with the profit of Rp. 23.982.375 and model-5 produces the lowest profit of Rp. 17,030,875.

The fourth stage, validation of output model would be compared to the average monthly production of mid year 2014. The comparison is done in terms of production as can be seen in Appendix 6. Total production of Actual was 137,5 kgs per month (approximately 31%) if compared to model-1 445.7 kgs per month (100%). This result was confirmated to Manager of Plant where found out that existing production was not optimal.

The sixth stage, interpretation of model output to real problems. These five solution models could be applied by the company according to the conditions existing demand. Model-1 provides the greatest profit than other models. Model-1 and -2 only produce 4 types of products, model -3 and -4 with 5 types of products and models-5 with 6 types of products. The more types of products produced will decrease the total profit. Despite having a low profit, model or stlevelgy that produces many types of products could minimize loss if a product has decreased sales. Next, carried out evaluation of usage of raw materials for each model. See the following Table 3.

Tabel 3. Usage of raw materials

Raw Materials	Model	Usage (kgs)	Availability (kgs)	Excess/Shortage (kgs)
Wet Cocoa bean	1	1566	1400	-166
	2	1548	1400	-148
	3	1422	1400	-22
	4	1207	1400	193
	5	1051	1400	349
Powder milk	1	2	50	48
	2	15	50	35
	3	19	50	31
	4	30	50	20
	5	30	50	20
Refined sugar	1	2	70	68
	2	15	70	55
	3	19	70	51
	4	30	70	40
	5	45	70	25

There is a shortage of wet cocoa beans for model 1, 2, and 3, where need to be met in order to achieve the production and profit level that fits with solution of each model.

Next, carried out evaluation of the usage of the capacity of the process (utilization level) for each machine. See Appendix 7 and Figure 1 below.

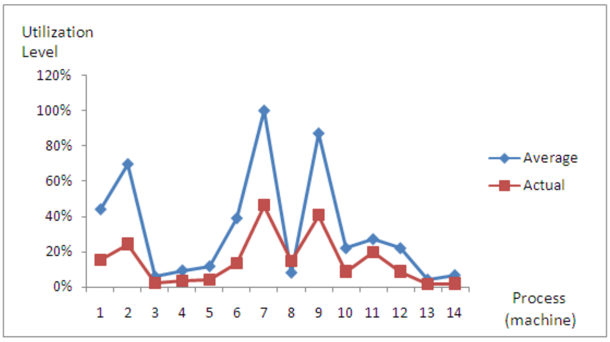

Figure 1. Utilization Level of Machines Capacity of Model (Average) and Actual.

It can be seen that bolming machine (7) and press machine (9) have the highest utilization level which means the finite resources. Increasing capacity of the machines would be able to increase the total profit. Difference in utilization levels among machines indicate a bottleneck in process. This condition should be avoided by balancing capacity of each production machine.

5. CONCLUSION

Model-1 gives maximum profit of Rp. 23.982.375 per month by producing four types of products ; pure powder 110.5 kgs, butter 59.5 kgs, candy-chocolate 7.6 kgs and scrub 268.1 kgs. The total production that could be achieved at the maximum profit is 445.7 kgs per month. On average models indicate that utilization level of machines capacity are not balanced, there are two machines above 80% and 10 machines below 10%. Production capacity of the plant could be increased by improving capacity of machines with high utilization level. This optimal solution need to be re-evaluated if there is a change in the parameters (such as raw material prices, profit products, machine capacity) significantly. Findings from this work could serve as useful guides to the management of Chokato in the formulation of production.

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Appendix 1. Coefficient of Raw Materials

Group	Percentage	Products	Percentage	Production (kg)	Wet Bean Cocoa (kg)	Coef. of Wet Bean Cocoa (kg)	Powder Milk(kg)	Coef. of Powder Milk (kg)	Refined Sugar(kg)	Coef. of Refined Sugar (kg)
A	50%	Pure powder	16.3%	50.8	158.7	3.1	0	0	0	0
		3in1 powder	16.3%	50.8	63.5	1.3	15.2	0.30	15.2	0.3
		Butter	17.5%	54.7	303.8	5.6	0	0	0	0
B	45%	Milk chocolate	15.0%	46.9	62.5	1.3	14.1	0.30	14.1	0.3
		Dark chocolate	15.0%	46.9	109.4	2.3	0	0	14.1	0.3
		Candy chocolate	15.0%	46.9	62.5	1.3	14.1	0.30	14.1	0.3
C	5%	Scrubs	5.0%	15.6	50.4	3.2	0	0	0	0
Total	100%		100.0%	312.5	810.8		43.4		57.4	
Stock per month (kg)					1400		50		70	

Appendix 2. Cycle Time of Process

Process Stage	Amount (Units)	Capacity (kgs)	Total Cycle Time (Hours)	Cycle Time per kgs (Hours)
Fermentation	5	38	120	3.16
Drying (under the sun)	1	120	18	0.15
Filtering (selectormachine)	1	20	0.50	0.03
Roasting (roaster machine)	1	10	0.40	0.04
Separation (winnowing machine)	1	1	0.05	0.05
Milling (nib milling machine)	1	1	0.17	0.17
Mixing (bolming machine)	1	20	72	3.60
Rarefaction (conching-1 machine)	1	20	24	1.20
Pressing (press machine)	1	1	1	1.00
Rarefaction (conching-2 machine)	1	1	0.17	0.17
Refrigeration (Refrigerator)	1	8	8	1.00
Rarefaction (conching-2 machine)	1	1	0.17	0.17
Sieving (sieving machine)	1	8	0.50	0.06
Packaging (packaging machine)	1	1	0.03	0.03

Appendix 3. Capacity of Machines

Process (Machines/Equipments)	Amount (Units)	Utilization Rate (%)	Operation Hour	Day Work per Month	Max. Capacity per Month (Hours)
Fermentation	5	95%	24	25	2850
Drying (under the sun)	1	95%	6	15	85.5
Filtering (selectormachine)	1	85%	8	25	170
Roasting (roaster machine)	1	85%	8	25	170
Separation (winnowing machine)	1	85%	8	25	170
Milling (nib milling machine)	1	85%	8	25	170
Mixing (bolming machine)	1	85%	24	25	510
Rarefaction (conching-1 machine)	1	85%	24	25	510
Pressing (press machine)	1	85%	8	25	170
Rarefaction (conching-2 machine)	1	85%	4	25	85
Refrigeration (Refrigerator)	1	90%	24	25	540
Rarefaction (conching-2 machine)	1	85%	4	25	85
Sieving (sieving machine)	1	85%	8	25	170
Packaging (packaging machine)	1	85%	8	25	170

Appendix 4. Solution of Models

Model	X_1	X_2	X_3	X_4	X_5	X_6	X_7	Z	Status
1	170	0	0	0	0	7.6	268.1	23,982,375	*Feasible*
2	170	0	0	0	0	7.6	268.1	23,982,375	*Feasible*
3	98.3	50	21.8	0	0	0	283.8	22,541,250	*Feasible*
4	70	50	50	0	0	13.5	256.4	22,465,125	*Feasible*
5	50	50	70	50	0	0	183.3	20,635,875	*Feasible*
6	50	50	70	50	50	0	83.3	19,760,875	*Feasible*
7	70	50	50	50	50	50	**-16.7**	19,573,375	*Unfeasible*
8	70	50	50	50	50	50	**-16.7**	19,573,375	*Unfeasible*

Appendix 5. Selected and Adjusted of Solutions

Model	Product (kgs)							Total Profit (Rp)	Total Production (kgs per month)	Total Production (kgs per day)
	1	2	3	4	5	6	7			
1	110.5	0	59.5	0	0	7.6	268.1	23,982,375	445.7	17.8
2	78.7	50	41.41	0	0	0	283.8	22,541,250	453.9	18.2
3	70	50	31.5	0	0	13.5	256.4	21,355,125	421.4	16.9
4	50	50	24.5	50	0	0	183.3	17,905,875	357.8	14.3
5	50	50	24.5	50	50	0	83.3	17,030,875	307.8	12.3

Appendix 6. Comparion Between Model and Actual in Production

Alternatives of Production	Product (kgs)							Total Production per Month (kgs)	Type of Products
	1	2	3	4	5	6	7		
model-1	110.5	0	59.5	0	0	7.6	268.1	445.7	4
model-2	78.7	50	41.4	0	0	0	283.8	453.9	4
model-3	70	50	31.5	0	0	13.5	256.4	421.4	5
model-4	50	50	24.5	50	0	0	183.3	357.8	5
model-5	50	50	24.5	50	50	0	83.3	307.8	6
Actual	22.3	22.3	24.1	20.6	20.6	20.6	6.9	137.5	7

Appendix 7. Utilization Level of Machines Capacity

Process (Machines/Equipments)	Utilization Level						
	Model-1	Model-2	Model-3	Model-4	Model-5	Average	Actual
Fermentation	49%	50%	47%	40%	34%	44%	15%
Drying (under the sun)	78%	80%	74%	63%	54%	70%	24%
Filtering (selectormachine)	7%	7%	6%	5%	5%	6%	2%
Roasting (roaster machine)	10%	11%	10%	8%	7%	9%	3%
Separation (winnowing machine)	13%	13%	12%	11%	9%	12%	4%
Milling (nib milling machine)	44%	45%	41%	35%	30%	39%	13%
Mixing (bolming machine)	100%	100%	100%	100%	100%	100%	46%
Rarefaction (conching-1 machine)	2%	0%	3%	12%	24%	8%	15%
Pressing (press machine)	100%	100%	89%	73%	73%	87%	40%
Rarefaction (conching-2 machine)	22%	25%	24%	20%	20%	22%	9%
Refrigeration (Refrigerator)	22%	24%	25%	28%	37%	27%	20%
Rarefaction (conching-2 machine)	22%	25%	24%	20%	20%	22%	9%
Sieving (sieving machine)	4%	5%	4%	4%	4%	4%	2%
Packaging (packaging machine)	8%	8%	8%	6%	5%	7%	2%